POTENTIAL AND ENVIRONMENTAL IMPACT OF INTEGRATED WASTE TREATMENT SITE MANAGEMENT IN MALANG DISTRICT

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ABSTRACT: Integrated Waste Management (TPST) should consider new paradigm in waste reduction and handling. This research proposes the implementation of Life Cycle Assessment (LCA) at a sustainable TPST, with the objective of analyzing the potential of technical waste recycling, analyzing environmental impact of waste recycling, and sustainable waste recycling scenario. The research conducted is to analyze the generation, composition, and characteristics of waste and secondary data that support. Based on the analysis data created scenarios in accordance with the condition of waste and its potential. The method to be used to assess the environmental impact is the LCA with Eco-Indicator analysis. Comparison of the size of the environmental impact assessment based on the SimaPro software program 8.3. The result of the data processing will be identified the part of the process causing the smallest environmental impact, so the scenario will be chosen to reduce the impact based on the LCA result. Environmental losses are divided into losses to human health, loss of ecosystem quality and resource loss. The results of the analysis show that the magnitude of the impact of each scenario, then the existing scenario produces the smallest environmental impact for all impact categories.

Keywords: Malang District, Potency and Environmental Impact, TPST.

1. Introduction

Garbage is a residual activity of human and / or natural processes in the form of solid (Laws of the Republic Indonesia Number 18, 2008). Solid Waste management is a systematic, thorough, and continuous activity that includes waste reduction and handling. Integrated waste treatment plant (TPST) is where the collection, sorting, reuse, recycling, processing, and final processing activities [Goverment Rules of the Republic Indonesia Number 81 of 2012 about Municipal Solid Waste Management and the like] take place. Waste generation is the amount of waste that arises from the community in units of volume or weight per capita per day, or extends the building, or extends the road (SNI, 2002). The composition of waste is any waste component that forms a unity, in percentage (%), usually expressed as% by weight or% volume, and classified in physical characteristics, chemical characteristics, biological characteristics (Tchobanoglous et al,1993). The Life Cycle Assessment (LCA) is a tool for assessing the environmental impacts and resources used through the life cycle of a product, in example from the acquisition of raw materials, production processes and phases of use, to waste management [ISO, 2006. ISO 14040 International Standard. In: Environmental Management – Life Cycle Assessment – Principles and Framework. International Organisation for Standardization, Geneva, Switzerland.]. LCA assesses the potential impact of waste and estimates results in relation to the proposed target (Güereca et al, 2006). Environmental impact analysis methods with LCA can use software assistance, such as Simapro. Four stages in LCA (Güereca et al, 2006) are goal and scope definition, life cycle inventory, life cyle impact assessment, and interpretation.

Malang Regency has some very active TPST among others TPST Mulyoagung Bersatu and TPST Pakisaji Maju. This area-scale TPST processes waste from surrounding villages and is based on 3R (Reduce, Reuse, Recycle) program in order to achieve future zero waste programs. Separation of objects of economic value so that they can be reused either in the form of the same or different from the original shape, and indirect recycling without any processing first, while the organic waste is processed into compost (Hardianto & Trihadiningrum, 2016). The key to the success of TPST is supported by intangible factors, such as: community support, leadership, motivation, mentoring, cooperation with markets, and so forth. The transfer of knowledge and technology regarding TPST also will assists government to develop TPST with 3R based activity, since knowledge and technology transfer could improve the knowledge and the capability of its transferee (Handoko et al, 2014; 2016; 2017; Handoko, 2017). In this case, bottom-up ideas and motivation can be the starting point of a TPST, as long as it gets support from the government (Hardianto & Trihadiningrum, 2014).

The purpose of this research is to analyze the technical potential of waste management operations and to analyze the environmental impact of waste management using LCA method with Eco-indicator analysis.

2. Methods

Research on the volume of waste that goes into the recycling facility is carried out by the sampling method. Calculating the volume of waste entering the recycling facility is based on the load-count analysis method, by calculating the total volume of waste received (Tchobanoglous et al, 1993). Measurement of garbage composition by sampling method with minimum sample size 100 kg for 8 days (ASTM, 2011). Sampling of the composition is carried out by quarterly method, which is stirred as uniformly as possible, then the waste is divided into four sections, and so on until a sample of 100 kg is obtained. The value of recovery factor is determined by measuring the weight of recyclable waste components, and calculated on the total weight of the waste component. Measurements of waste densities are carried out randomly in various types of collecting vehicles. Heavy measurements in collecting vehicles are weighed first. Weighing is done by using the scales before being placed into the reception area. Determining the volume of waste based on the volume of collecting vehicles, so the volume can be calculated by using the volume calculation. The determination and type of scenario is determined on the planned LCA:

- Baseline scenario is a scenario if waste management is not carried out at the recycling facility, so that the waste is directly disposed to the final processing place (TPA).
- Existing scenario is a scenario if recycling of dry waste and composting is integrated.

3. Result and Discussion

3.1 Generation, Composition, and Waste Characteristics

Analysis of waste generation that goes to TPST is by measuring the length, width, and height of garbage contained in garbage transport vehicles. Some transport vehicles collect garbage more than once a day. Waste volume data can be seen in Table 1. The analysis of waste composition is done by sorting by type, for 8 consecutive days as shown in Table 2.

The percentage of garbage composition shows that the waste that has the highest composition is organic waste. TPST Pakisaji Maju consists of 25.75% of organic waste and 35.29% of food waste, while TPST Mulyoagung Bersatu food waste is 23.78% and garden waste is 46.67%.

The weight of waste in collecting vehicles for TPST Pakisaji Maju is 216.230 kg / m3 average, while TPST Mulyoagung Bersatu is 211.73 kg / m3 average. So the weight of the waste is :

Weight of waste in TPST Pakisaji Maju = 12.62 m^3/day x 216.23 kg/m^3
= 2728.82 kg/day.

Weight of waste in TPST Mulyoagung Bersatu = 74.62 m^3/ day x 211.73 Kg/m^3
= 15799.29 kg/day.

Table 1 Waste Volume entering to the TPST

Days to	Waste Volume (m^3)	
	TPST Pakisaji Maju	TPST Mulyoagung Bersatu
1	15.27	69.77
2	12.85	79.38
3	14.87	79.07
4	14.18	83.07
5	13.89	69.90
6	8.46	63.27
7	13.85	69.34
8	7.63	83.14
Average	12.62	74.62

Table 2 Waste Composition in TPST

Type of Waste		Composition (%)	
		TPST Pakisaji Maju	TPST Mulyoagung Bersatu
Organic Waste	Food waste	35.29	23.78
	Garden waste	25.75	46.67
Plastic	HDPE	4.53	3.65
	LDPE	2.60	4.11
	PET	5.01	4.38
	Mixed	6.72	1.04
Paper and cardboard	Office paper	0.53	0.39
	Newspaper	0.68	1.15
	Magazine	0.95	0.01
	Books	0.41	0.32
	Mixed paper	1.04	3.50
	cardboard	3.13	2.28
Diapers		6.66	2.80
Cable		0.17	0.28
Wood		0.92	0.66
Hazardous		0.33	0.07
Fabric/Textiles		2.39	1.57
Glass		2.53	1.21
Ribbon		0.52	0.43
Aluminium can		0.54	1.09
Metal		0.45	0.14
Leather		1.01	0.11
Sterofoam		0.58	0.38
Total		100	100

3.2 Potency of Waste Reduction

The result of waste mass balance calculation and the potential of waste reduction type from the existing scenario is presented in the flow diagram in Figure 1 and Figure 2.

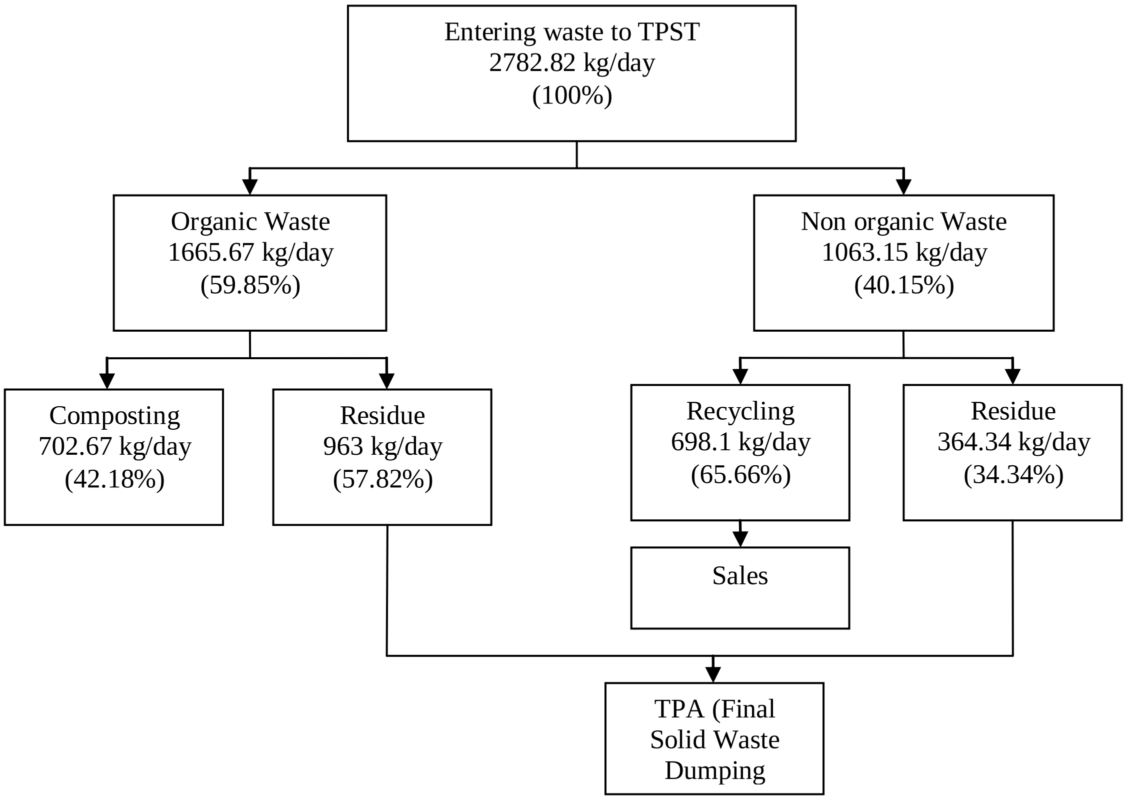

Figure 1 Mass Balance of existing scenario in TPST Pakisaji Maju

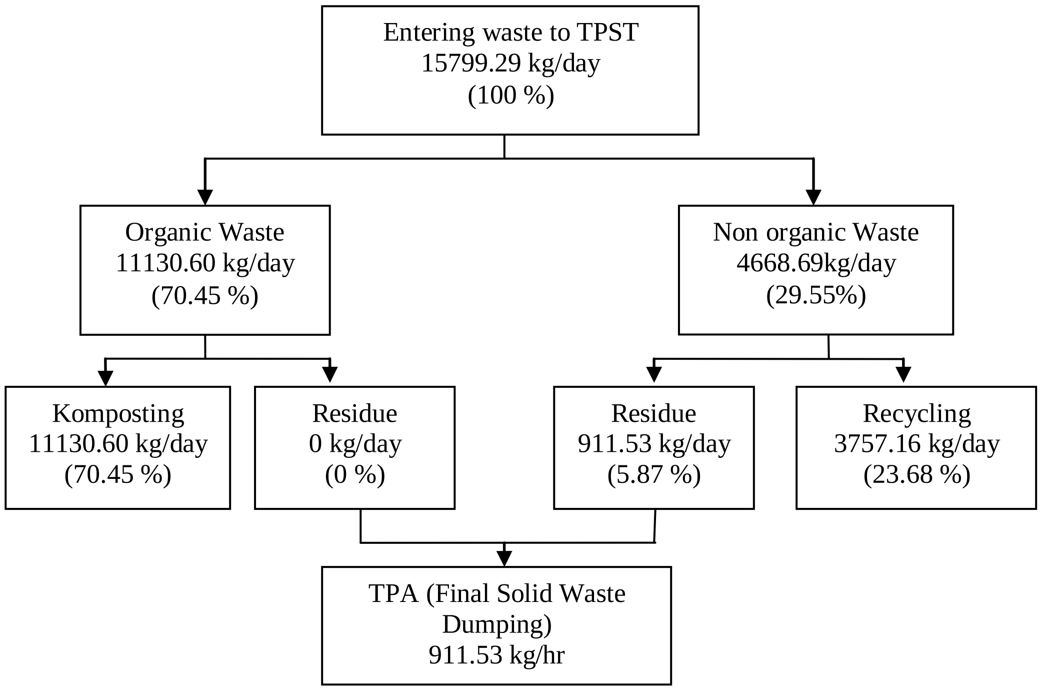

Figure 2 Mass Balance of existing scenario in TPST Mulyoagung Bersatu

3.3 Life Cycle Assessment (LCA)

3.3.1 Goal and Scope Definition

The purpose of LCA use in this research is to analyze the environmental impact in TPST, as well as the scenario of waste recycling which has the smallest environmental impact. Limitations of LCA use in this study are the functions used in the LCA is the generation, composition, and characteristics of waste that goes into the recycling facility. The environmental impacts analyzed are adjusted to the impact data inventory.

3.3.2 Life Cycle Inventory (LCI)

The data that are inventoried in this research are organic waste for composting process, and non-organic waste for recycling. Raw materials are calculated based on the generation and composition of waste per kilogram. Additional materials include for composting activities, fuel for compost machine, plastic counter machine, electricity.

3.3.3 Life Cycle Impact Assessment (LCIA)

The impact assessment phase is done using SimaPro software version 8.3.0, the method used is Eco-Indicator 99 (E), as can be seen in Table 3.

3.3.4 Interpretation

Environmental impact losses are divided into losses to human health (Climate change, Ozone layer depletion, Carcinogens, Respiratory inorganic, Respiratory organic, Radiation), loss of Ecosystem (Ecotoxicity, Acidification / Eutrofication, Land use) and resources (Minerals, Fossil fuel). The results of the environmental impact characteristics of each category in the TPST show that in terms of the magnitude of the impacts of each scenario, the exiting scenario produces the smallest environmental impact for all impact categories.

Table 3 Result of Environmental Impact Characterization in TPST

Impact Category	Unit	TPST Pakisaji Maju		TPST Mulyoagung Bersatu	
		LC baseline baseline	LC existing scenario	LC baseline baseline	LC existing scenario
Carcinogens	DALY	0.0271	0.0252	0.0389	0.0237
Respiratory organic	DALY	0.000233	0.000225	0.000345	0.000282
Respiratory inorganic	DALY	0.411	0.411	0.417	0.414
Climate change	DALY	0.048	0.0478	0.0507	0.0489
Radiation	DALY	0.000556	0.000556	0.000597	0.000595
Ozone layer depletion	DALY	1.54×10^5	1.53×10^5	0.0000343	0.0000327
Ecotoxicity	PAF*m2yr	9.69×10^4	9.44×10^4	127000	99000
Acidification/ Eutrofication	PDF*m2yr	3.93×10^3	3.91×10^3	4100	3980
Land use	PDF*m2yr	5.83×10^5	5.83×10^5	606000	606000
Minerals	MJ surplus	8.11×10^4	8.11×10^4	81400	81100
Fossil fuels	MJ surplus	2.33×10^5	2.33×10^5	249000	238000

4. Conclusion

A comparison of the magnitude of the impact of each scenario based on the Life Cycle Assessment (LCA) study indicates that the existing scenario option is that if an integrated dry recycle and composting recycling are produced, the smallest environmental impacts for all impact categories. The selection of a recycling facility model adapts to an integrated recycling facility with a community involvement system, resulting in less environmental impact.

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